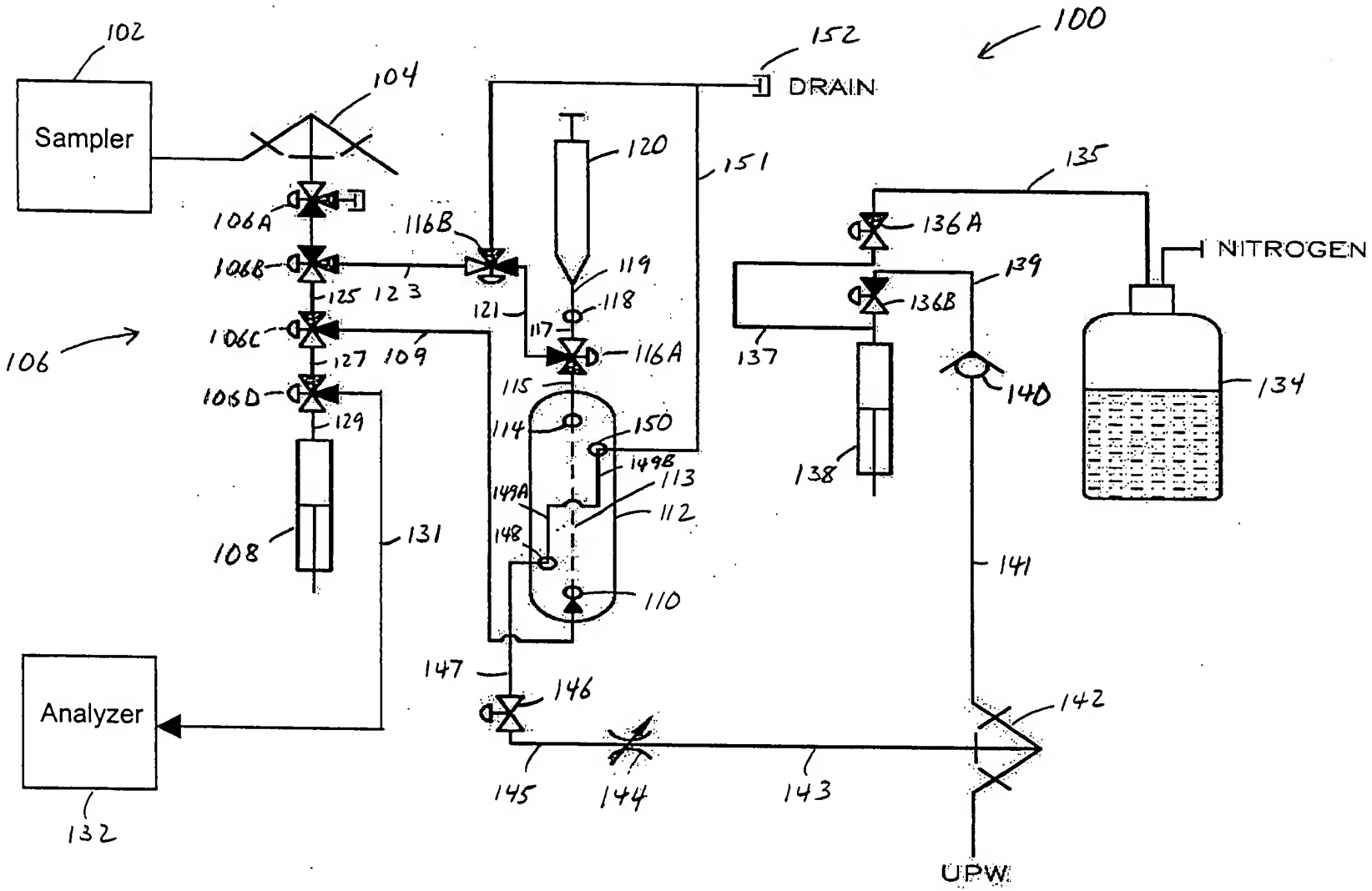
100
102
Sampler
104
106
106A
106B
106C
106D
108
109
110
112
113
114
115
116A
116B
117
118
119
120
121
123
125
127
129
131
132
134
135
136A
136B
137
138
139
140
141
142
143
144
145
146
147
148
149A
149B
150
151
152
DRAIN
NITROGEN
Analyzer
UPW

FIG. 1

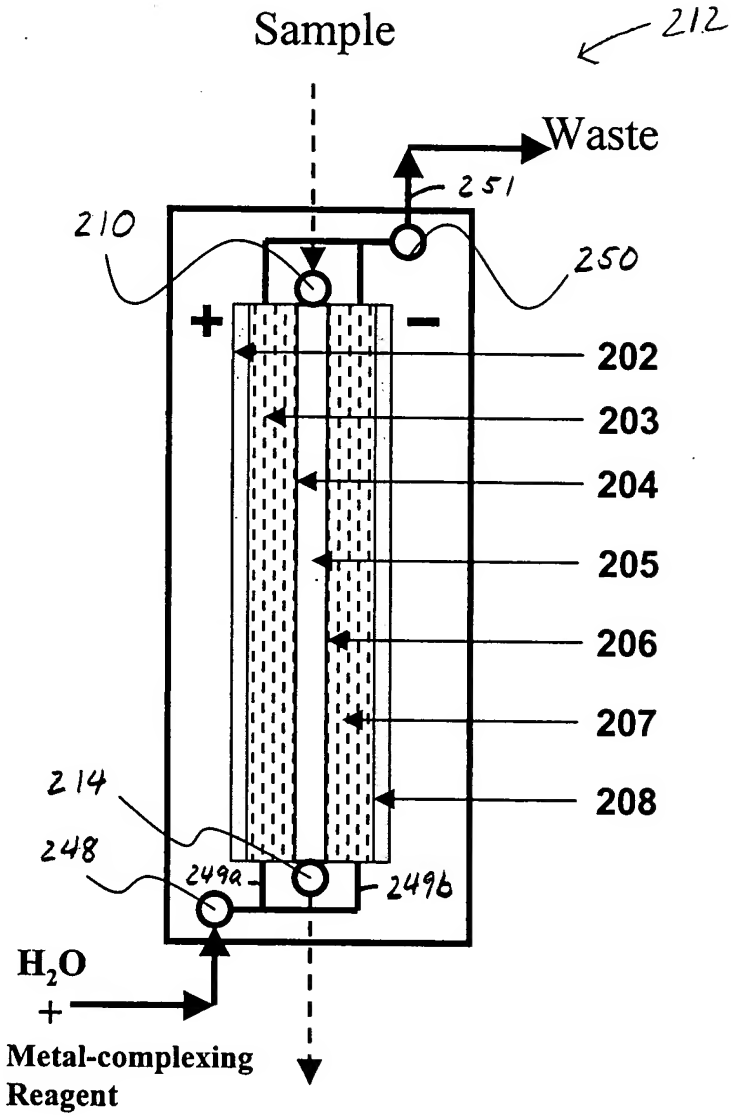
Sample
212
Waste
251
210
250
+
−
202
203
204
205
206
207
208
214
248
249a
249b
H_2O
+
Metal-complexing
Reagent

FIG. 2

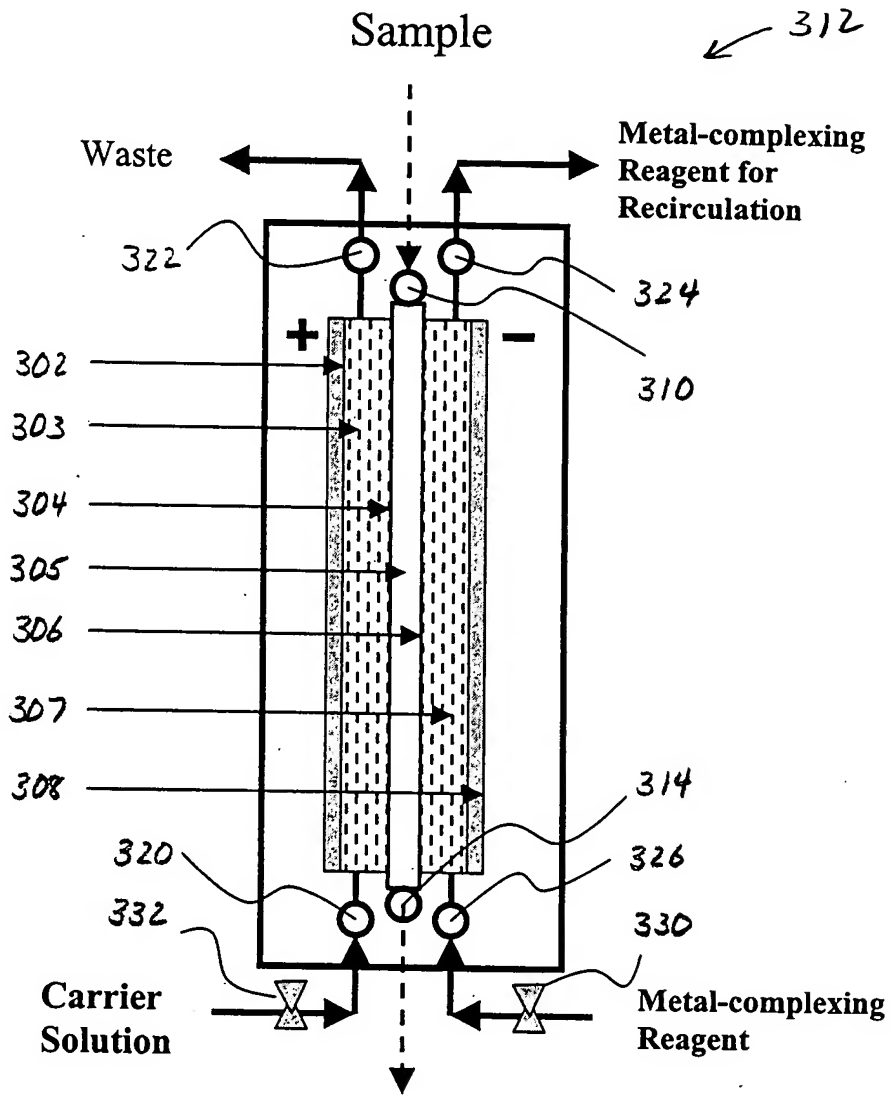
Sample
312
Waste
Metal-complexing Reagent for Recirculation
322
324
310
+
−
302
303
304
305
306
307
308
314
320
326
332
330
Carrier Solution
Metal-complexing Reagent

FIG. 3A

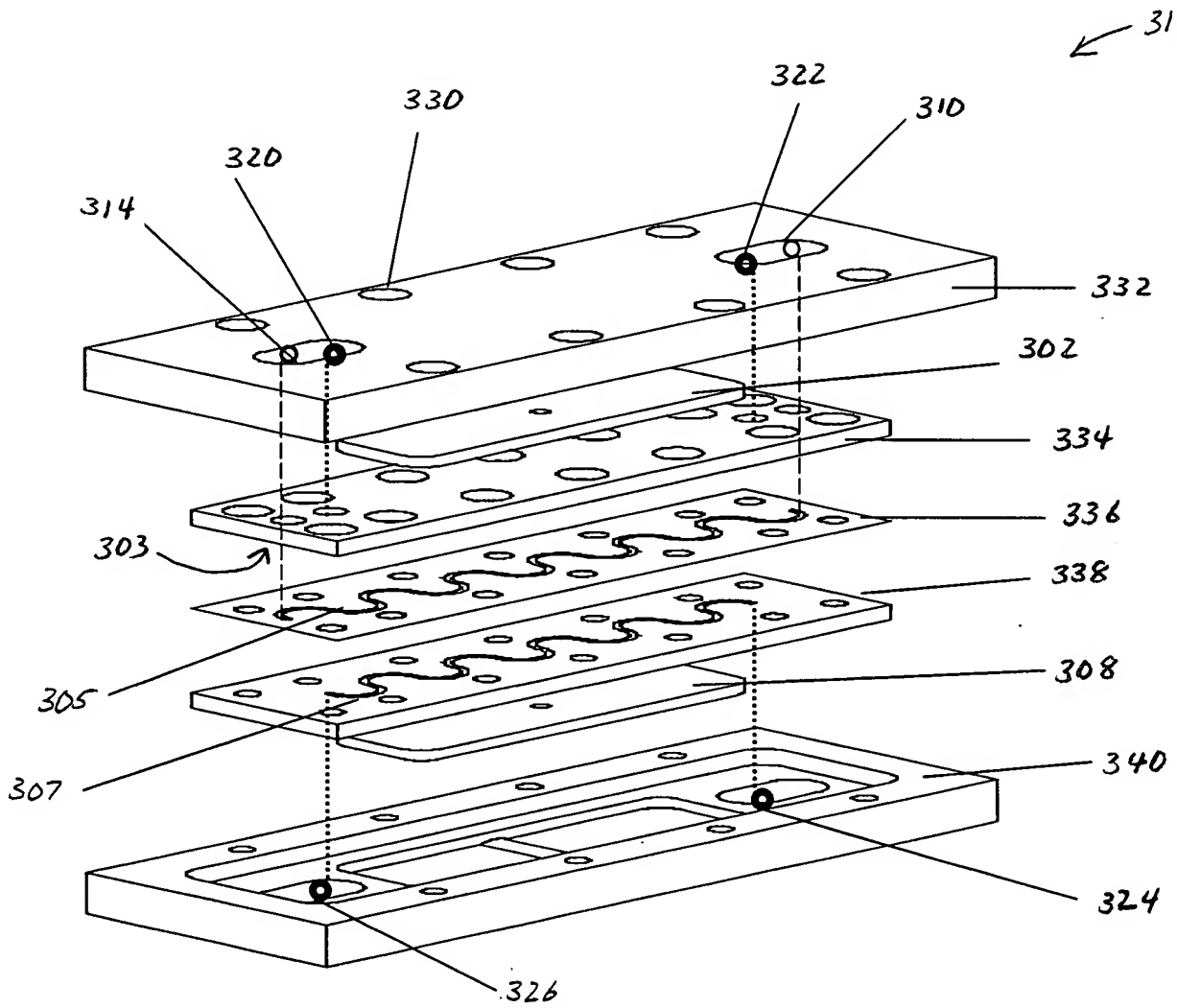
312
322
330
310
320
314
332
302
334
336
303
338
305
308
307
340
324
326

FIG. 3B

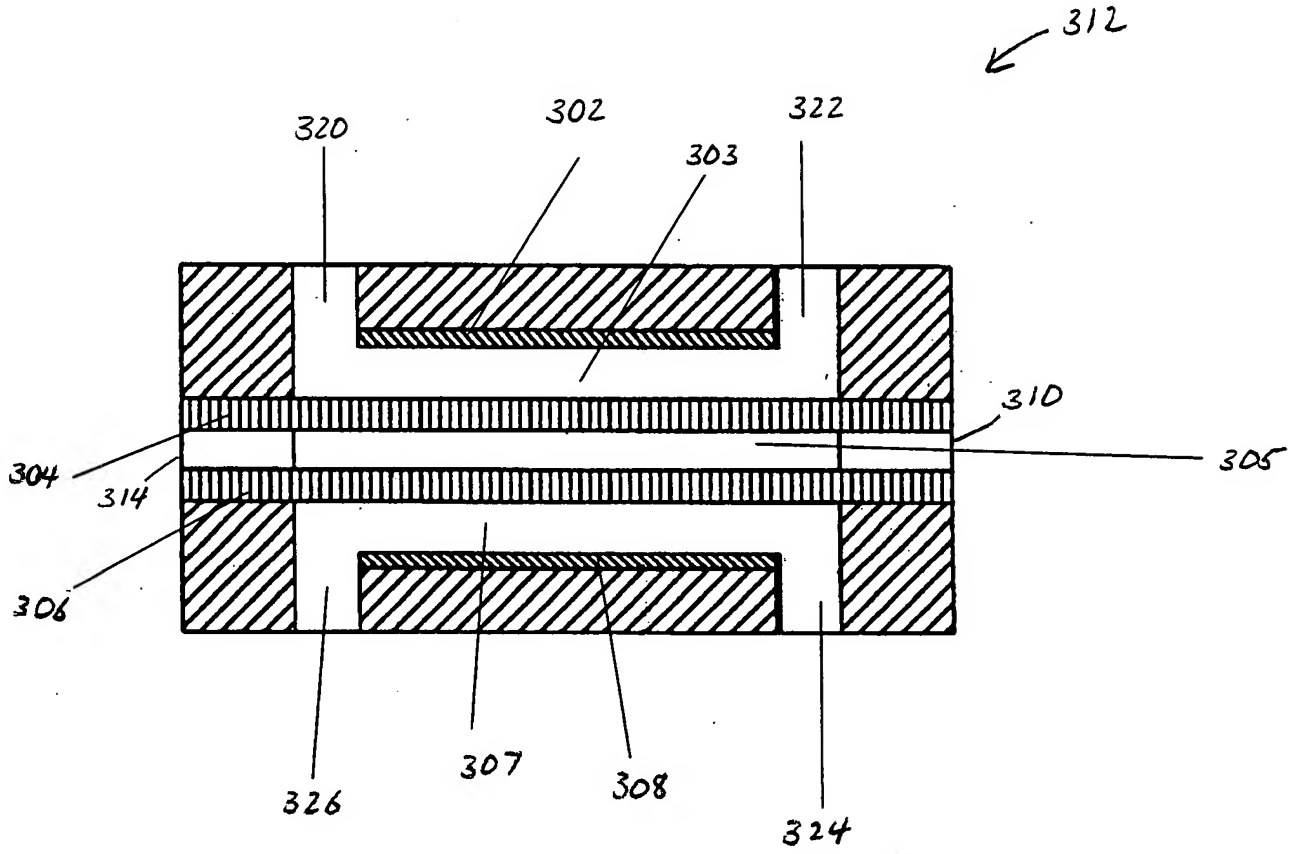

FIG. 3C

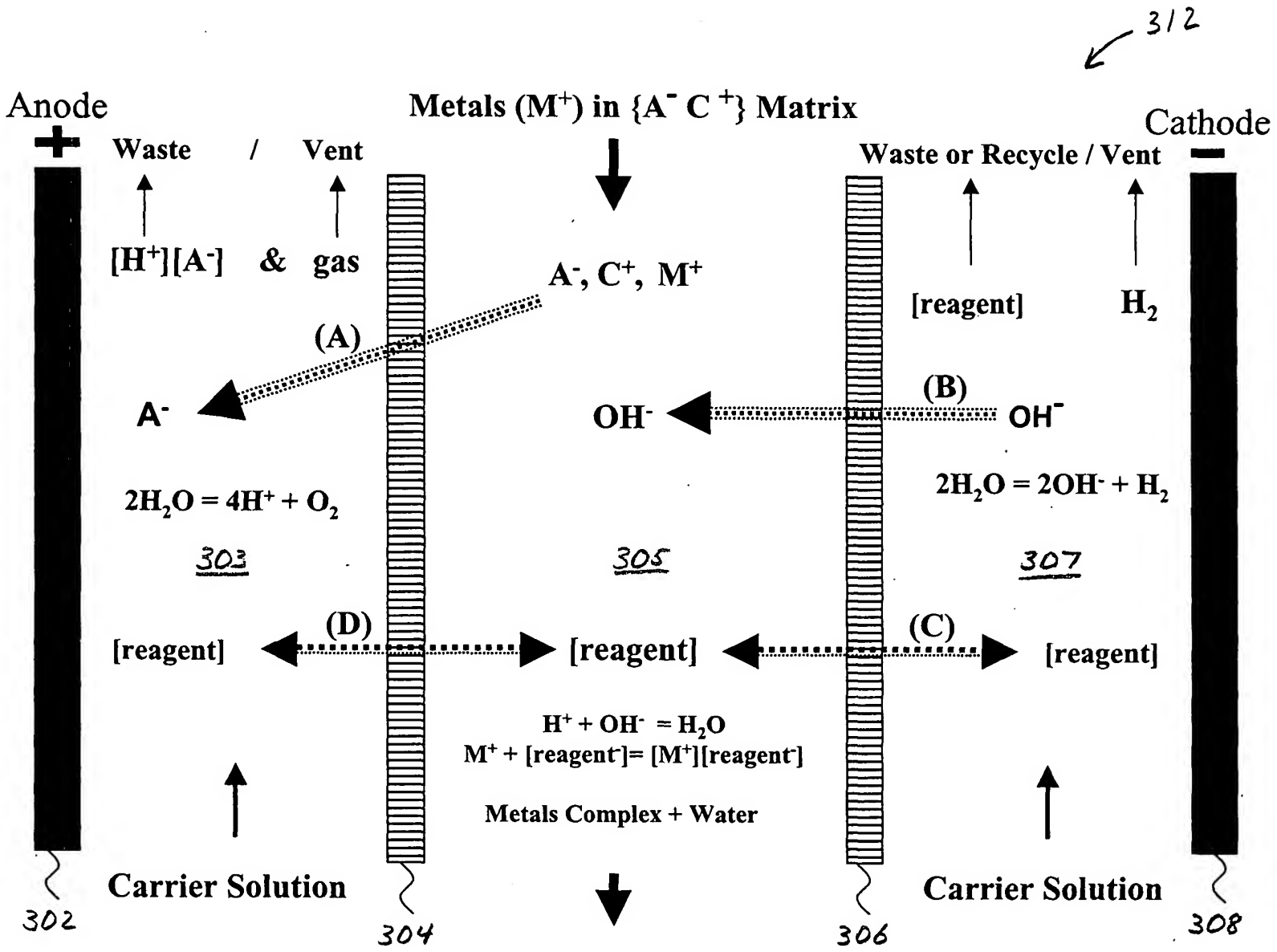
312
Anode
Metals (M^+) in $\{A^- C^+\}$ Matrix
Cathode
Waste / Vent
Waste or Recycle / Vent
$[H^+][A^-]$ & gas
A^-, C^+, M^+
[reagent]
H_2
(A)
(B)
A^-
OH^-
OH^-
$2H_2O = 4H^+ + O_2$
$2H_2O = 2OH^- + H_2$
303
305
307
(D)
(C)
[reagent]
[reagent]
[reagent]
$H^+ + OH^- = H_2O$
$M^+ + [reagent^-] = [M^+][reagent^-]$
Metals Complex + Water
Carrier Solution
Carrier Solution
302
304
306
308

FIG. 4A

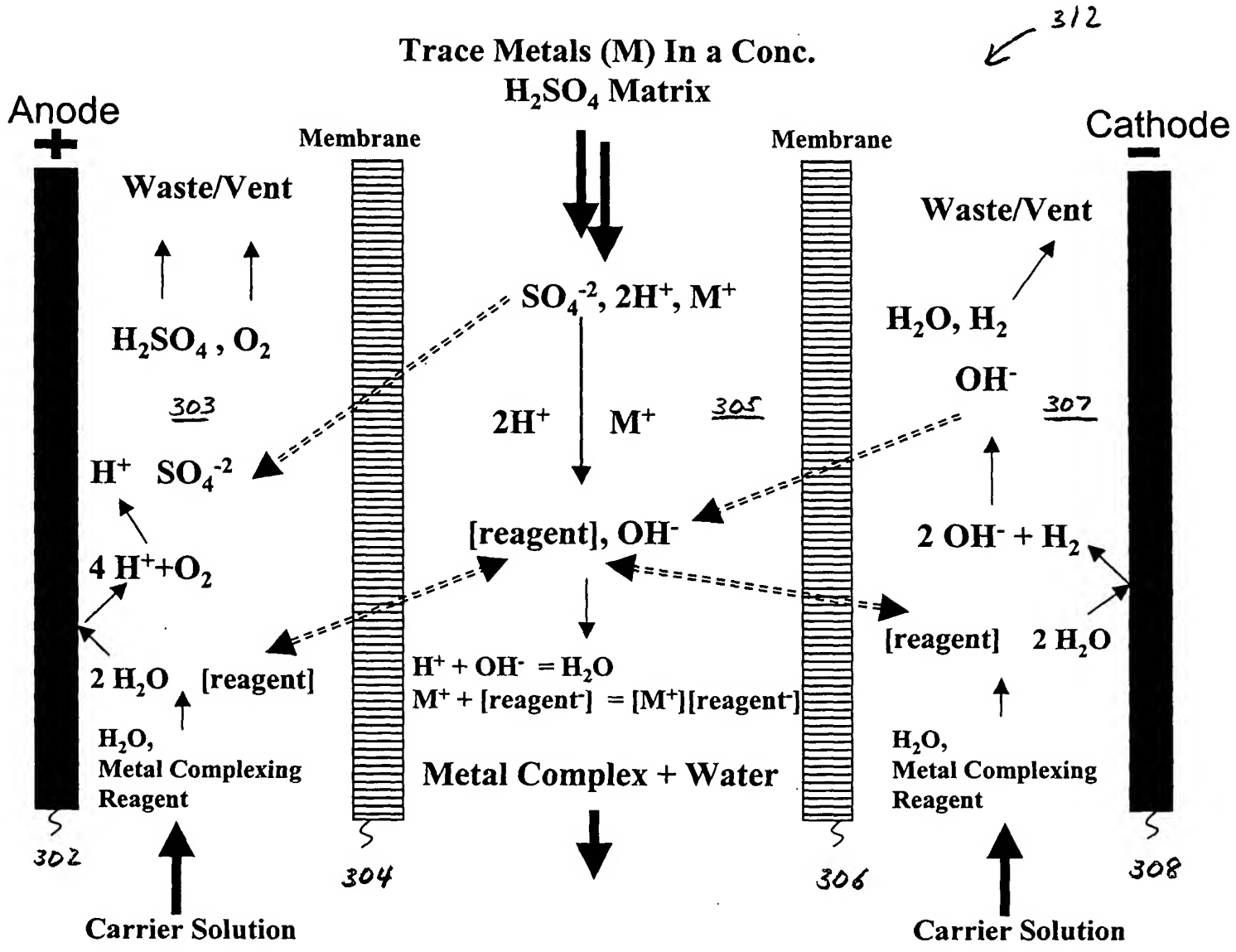
312
Trace Metals (M) In a Conc.
H_2SO_4 Matrix
Anode
Membrane
Membrane
Cathode
Waste/Vent
Waste/Vent
SO_4^{-2}, $2H^+$, M^+
H_2SO_4 , O_2
H_2O, H_2
OH^-
303
305
307
$2H^+$
M^+
H^+ SO_4^{-2}
[reagent], OH^-
$2\ OH^- + H_2$
$4\ H^+ + O_2$
[reagent]
$2\ H_2O$
$H^+ + OH^- = H_2O$
$M^+ + [reagent^-] = [M^+][reagent^-]$
$2\ H_2O$
[reagent]
H_2O,
Metal Complexing
Reagent
Metal Complex + Water
H_2O,
Metal Complexing
Reagent
302
304
306
308
Carrier Solution
Carrier Solution

FIG. 4B

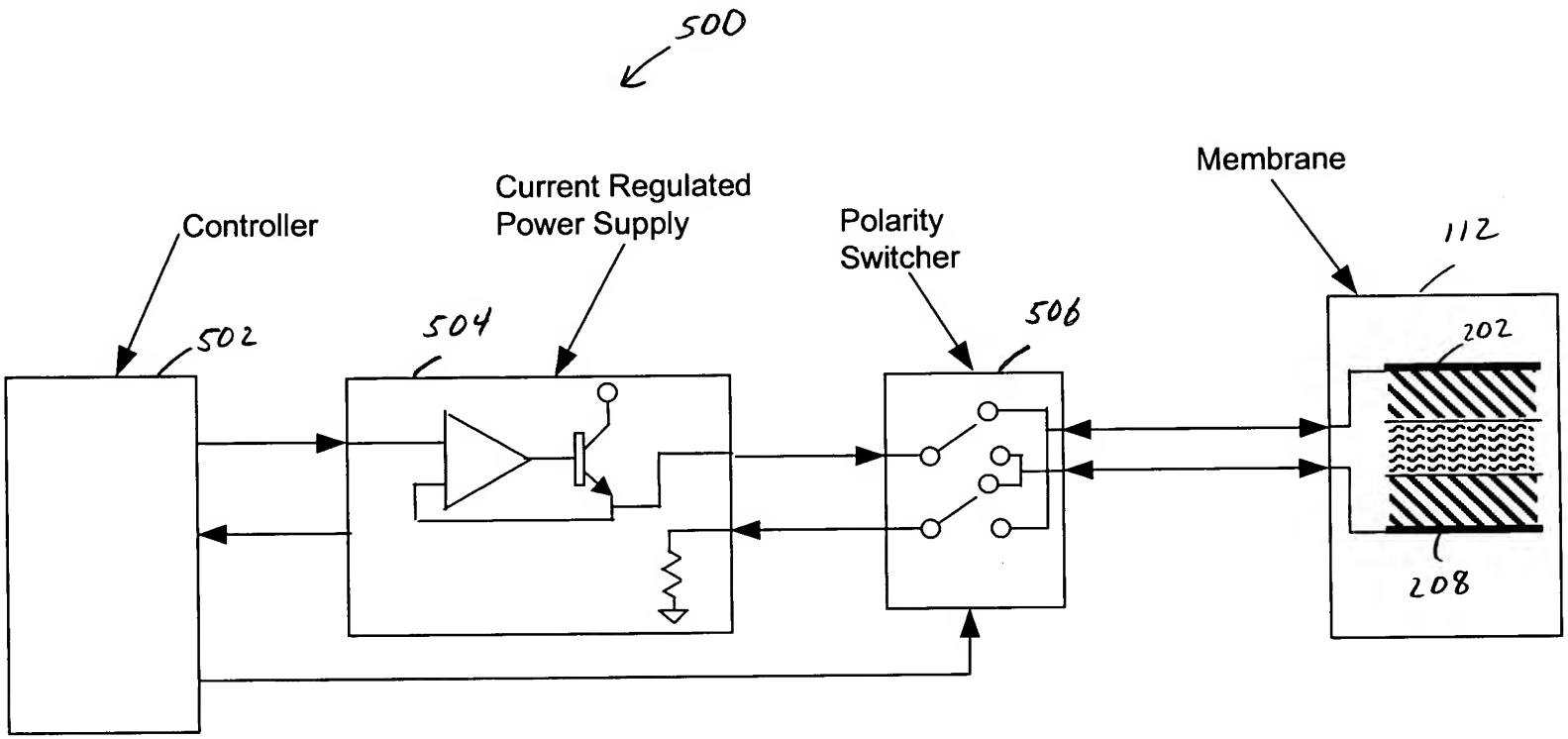
500
Controller
502
Current Regulated
Power Supply
504
Polarity
Switcher
506
Membrane
112
202
208

FIG. 5

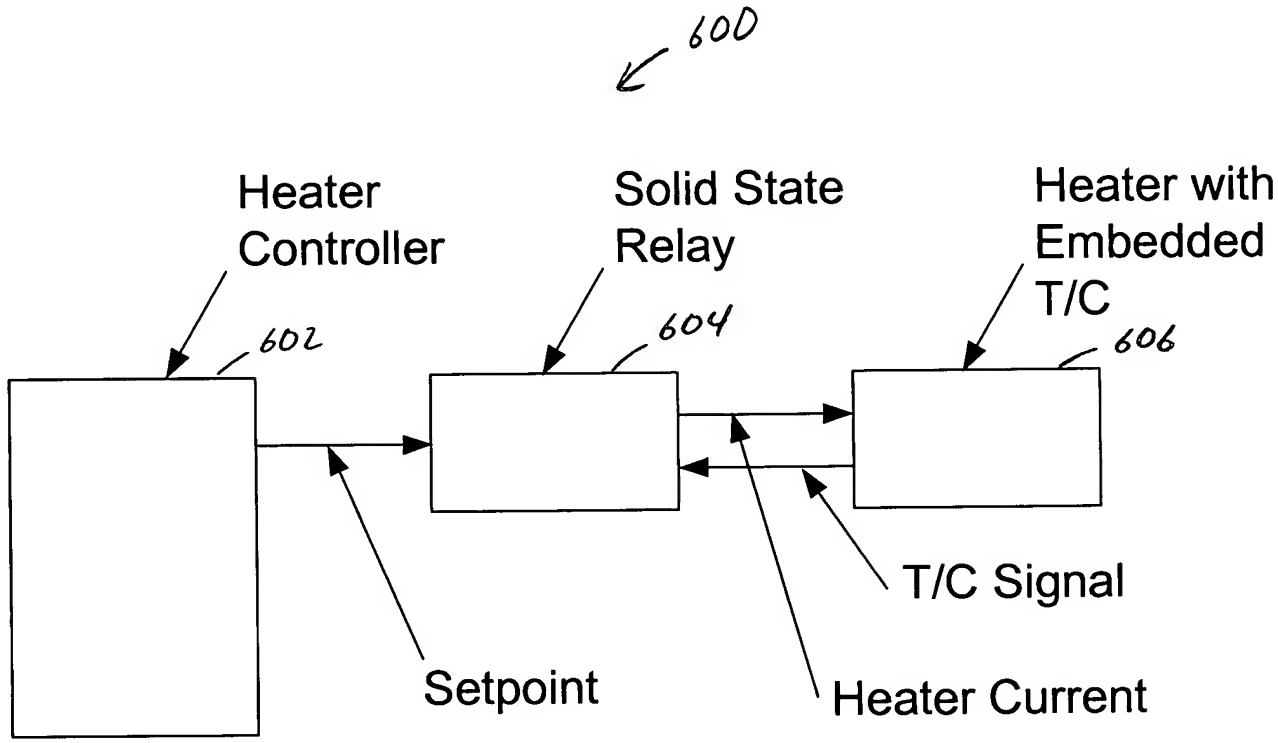
600
Heater Controller
602
Solid State Relay
604
Heater with Embedded T/C
606
T/C Signal
Setpoint
Heater Current

FIG. 6

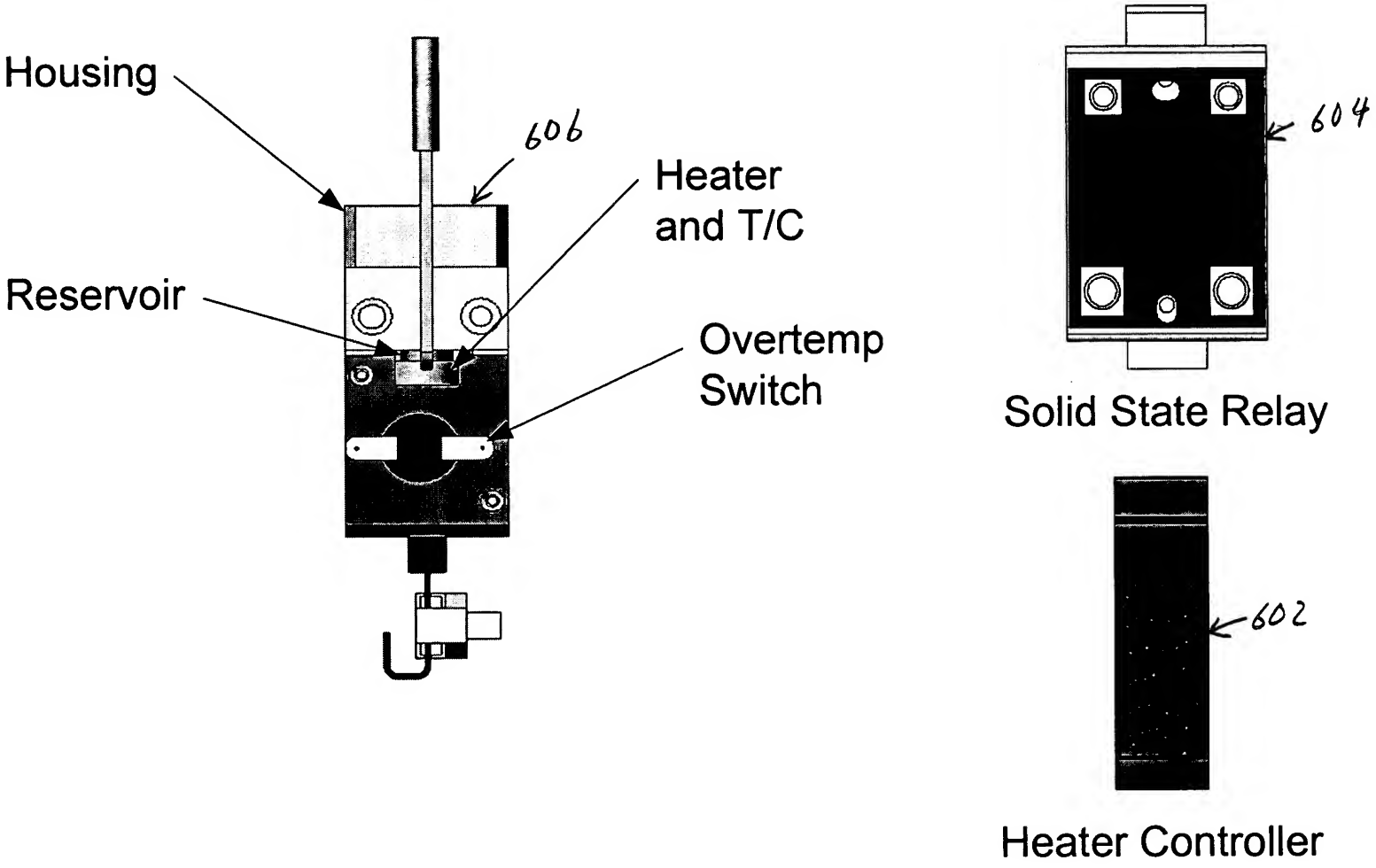
Housing
606
Heater
and T/C
Reservoir
Overtemp
Switch
604
Solid State Relay
602
Heater Controller

FIG. 7

```
' $Workfile: Membrane.config $
'
membrane_A_enable = 1
membrane_D_enable = 1

membrane.sensor.antibubble.retry=10        ' # of times to requery optical sensor when air is detected
membrane.sensor.antibubble.retry.delay= 1 ' delay (seconds) between requeries of sensor when air is
detected

' Solution used with membrane
'
membrane_A_solutionname = HF
membrane_D_solutionname = H2SO4

' HF
'
HF_operating_vol = 1600              ' implied volume of solution in syringe before membrane operation
begins
HF_carrier_solution = HF                   ' ? no consequence
HF_carrier_syr_speed = 10                  ' ? no consequence
HF_refill_speed = 30                       ' speed to draw from reservoir back to the syringe

HF_stage1_neutralization_speed = 10 ' speed to push through membrane, in microliters/sec
HF_stage1_cycles = 2                       ' times to repeat this run
HF_stage1_current = 250              ' milliamps
HF_stage1_polarity = 0                     ' -1 = oscillate, 0 = negative, 1 = positive

HF_stage2_cycles = 2
HF_stage2_polarity = 0
HF_stage2_neutralization_speed = 10
HF_stage2_current = 200

UPW_clean_num_cycles=2
UPW_clean_refill_speed=30                  ' speed UPW is drawn from resevoir to syringe
UPW_clean_neut_speed=10                    ' speed UPW is run through the membrane

HF_num_stages=2          ' increment this, and add additional HF_stageX parameters to have more stages
```

FIG. 8

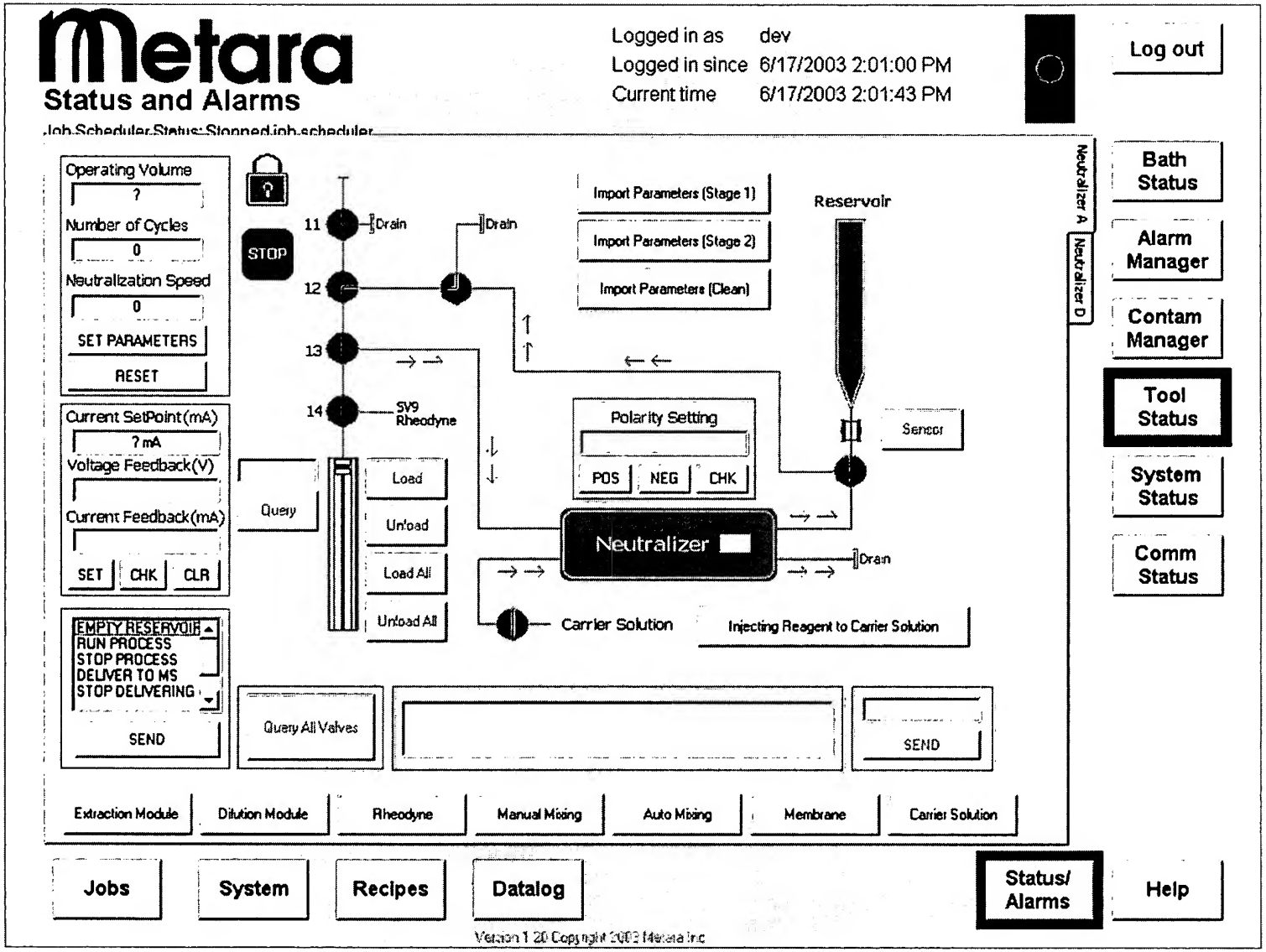
Metara
Status and Alarms
Logged in as dev
Logged in since 6/17/2003 2:01:00 PM
Current time 6/17/2003 2:01:43 PM
Log out
Operating Volume
Number of Cycles
Neutralization Speed
SET PARAMETERS
RESET
Current SetPoint(mA)
Voltage Feedback(V)
Current Feedback(mA)
SET
CHK
CLR
EMPTY RESERVOIR
RUN PROCESS
STOP PROCESS
DELIVER TO MS
STOP DELIVERING
SEND
STOP
11
12
13
14
Drain
Drain
SV9
Rheodyne
Query
Load
Unload
Load All
Unload All
Import Parameters (Stage 1)
Import Parameters (Stage 2)
Import Parameters (Clean)
Reservoir
Polarity Setting
POS
NEG
CHK
Sensor
Neutralizer
Drain
Carrier Solution
Injecting Reagent to Carrier Solution
Query All Valves
SEND
Neutralizer A
Neutralizer D
Bath Status
Alarm Manager
Contam Manager
Tool Status
System Status
Comm Status
Extraction Module
Dilution Module
Rheodyne
Manual Mixing
Auto Mixing
Membrane
Carrier Solution
Jobs
System
Recipes
Datalog
Status/ Alarms
Help

FIG. 9

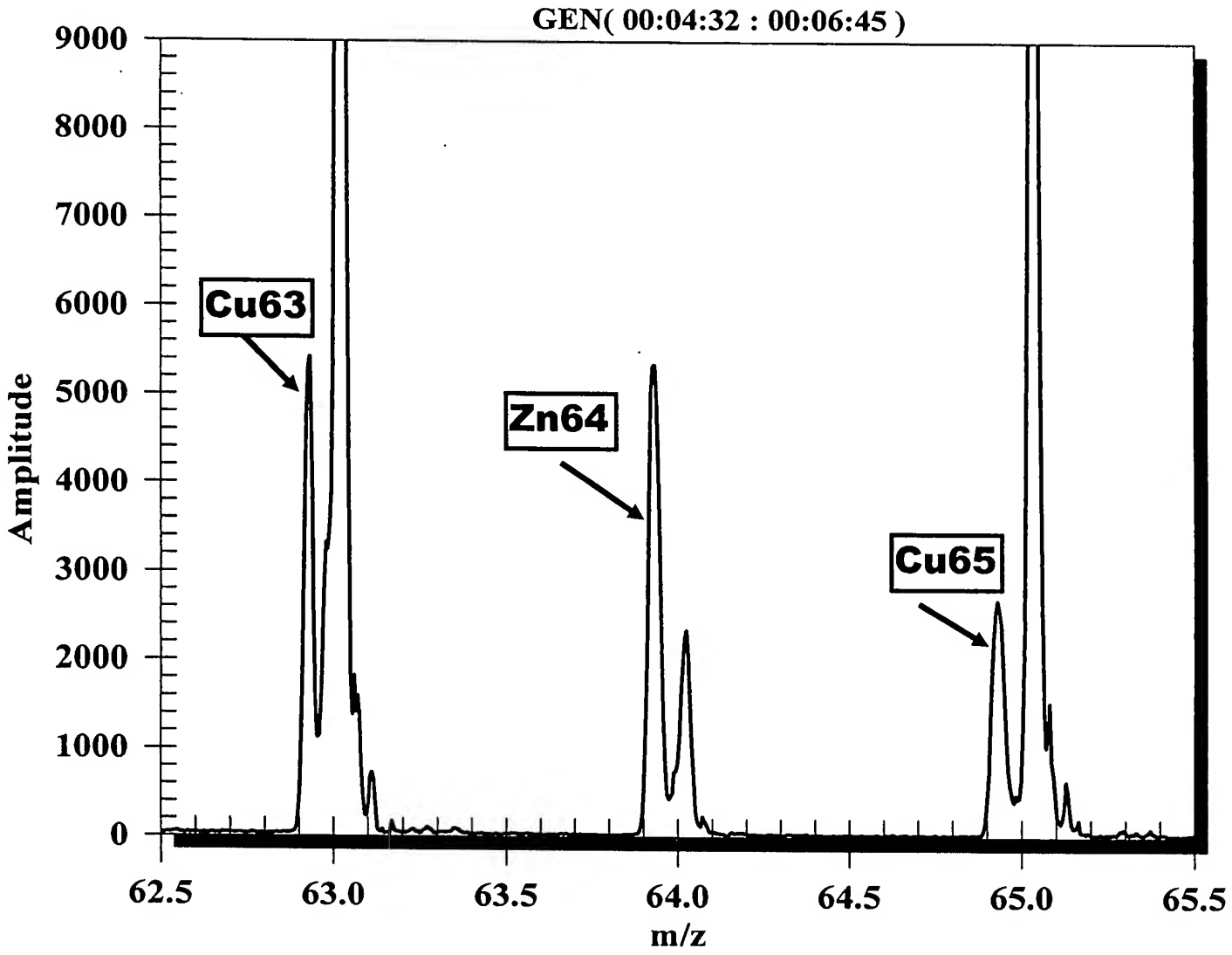
Elements in Sulfuric Acid Matrix
GEN(00:04:32 : 00:06:45)
Amplitude
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Cu63
Zn64
Cu65
62.5
63.0
63.5
64.0
64.5
65.0
65.5
m/z

FIG. 10

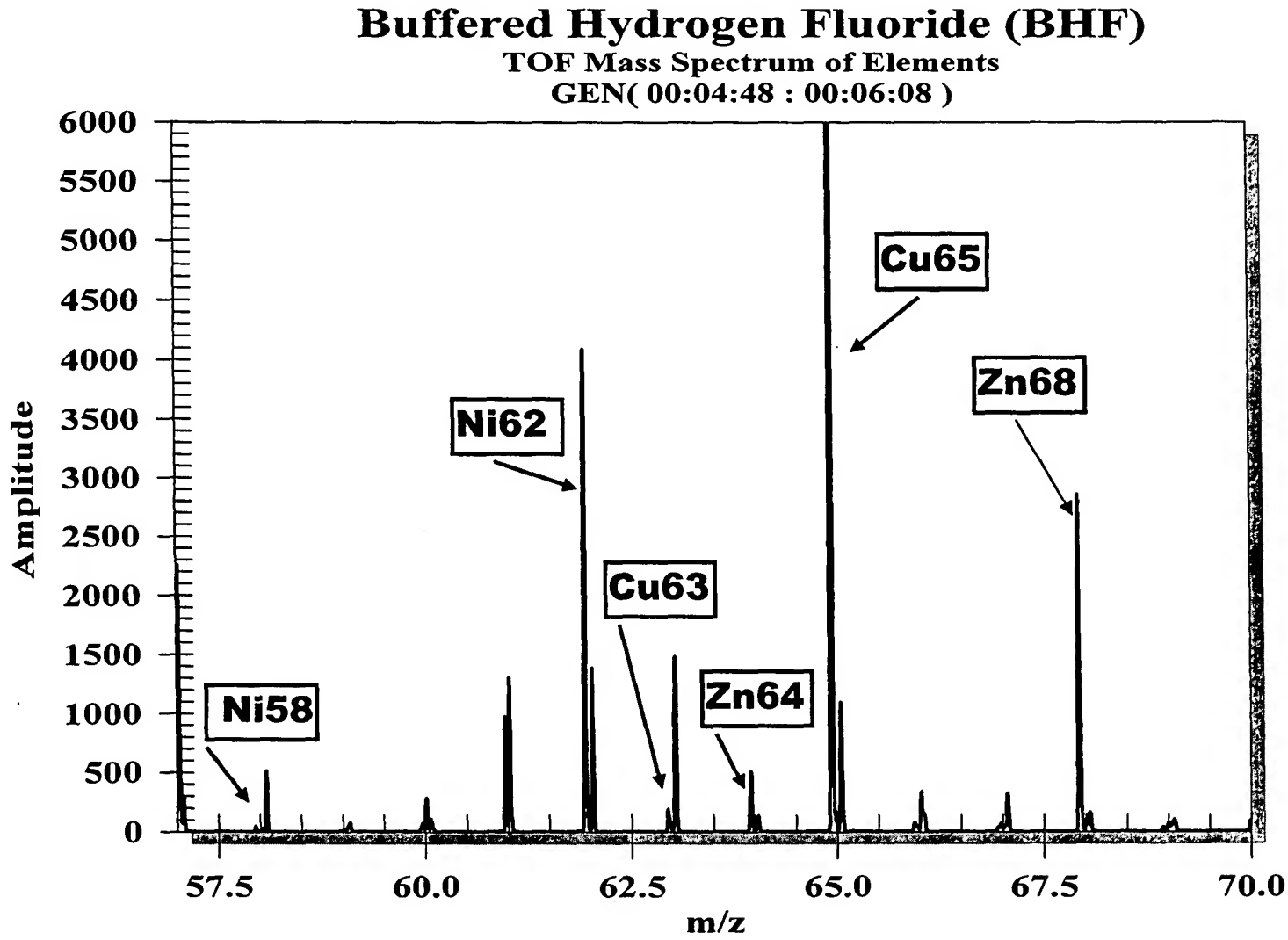
Buffered Hydrogen Fluoride (BHF)
TOF Mass Spectrum of Elements
GEN(00:04:48 : 00:06:08)
Amplitude
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Ni58
Ni62
Cu63
Zn64
Cu65
Zn68
57.5
60.0
62.5
65.0
67.5
70.0
m/z

FIG. 11